# GEOMORPHIC INVESTIGATIONS AT CONTAMINATED SITES

#### INSIGHTS FROM GEOMORPHOLOGY

Maureen K. Corcoran
Research Geologist
Geotechnical and Structures Laboratory
U.S. Army Engineer Research and Development Center

#### TOPICS TO BE PRESENTED

- Long-term stability of contaminated sediments
- Fundamentals of engineering geomorphology
- Geomorphology in managing contaminated sediments
- Framework for geomorphological investigations of contaminated sediment

# Geomorphological Investigations of Contaminated Sediment

### Goal

Provide program managers, scientists, and engineers with a comprehensive analysis of historic, present, and future geomorphologic and sedimentary conditions and processes that control or influence the location, movement, and burial of contaminated sediments

### KEY QUESTIONS: CONTAMINATED SEDIMENTS

- Where do contaminated sediments occur?
- What are the geometries of contaminated sediment bodies?
- What are the processes controlling long-term stability?
- How do the magnitude, frequency, and duration of sediment processes vary in time and space?
- What is the average sedimentation rate of the river?

#### **GEOMORPHOLOGY: DEFINITIONS**

**Geomorphology:** The study and analysis of landforms and landscapes, the processes and factors that form them, and their evolution in time and space.

Engineering Geomorphology: The application of the science of geomorphology to the planning, design, construction, and/or operation of engineering projects.

#### A GEOMORPHIC EQUATION

$$L = f(P, M) \Delta T, \Delta S$$

#### Where:

L = Landform (sediment body)

P = Processes

**M** = Material

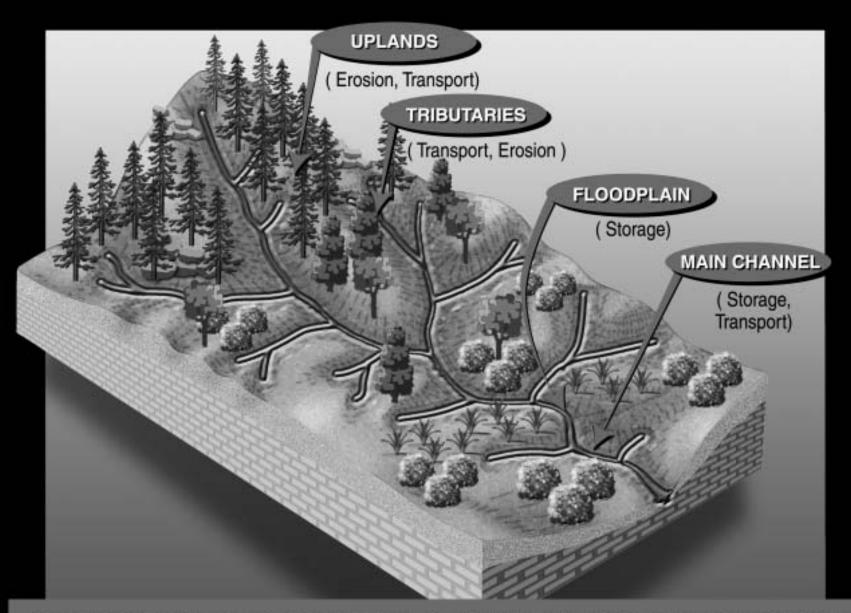
T = Time

S = Space

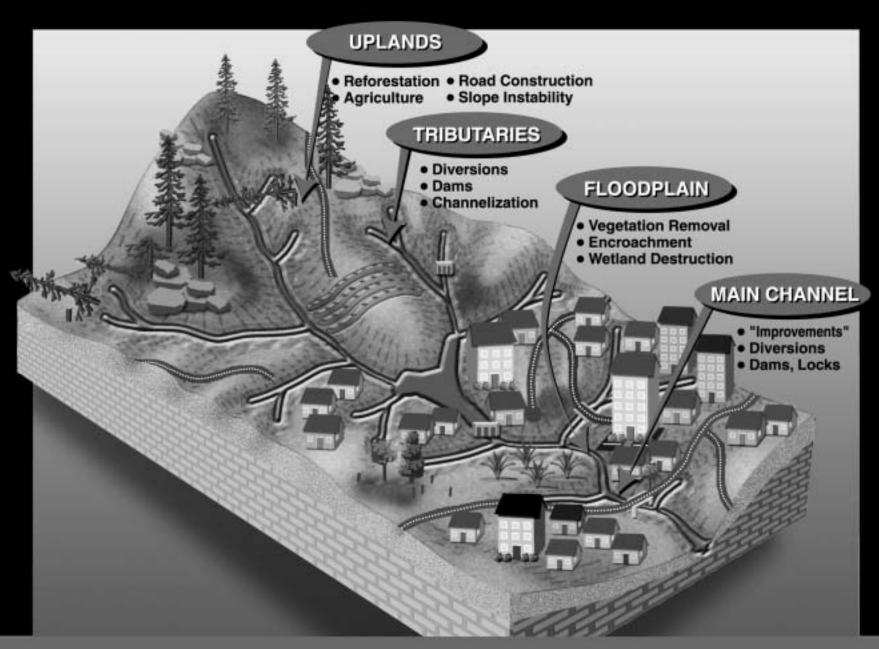
# GEOMORPHOLOGICAL CONCEPTS: SEDIMENT STABILTY

## Geomorphological systems, elements, processes, and uniformity

- Elements-typical surface and subsurface conditions
- Geomorphic process-landform/sediment products
- Uniformity and environmental change

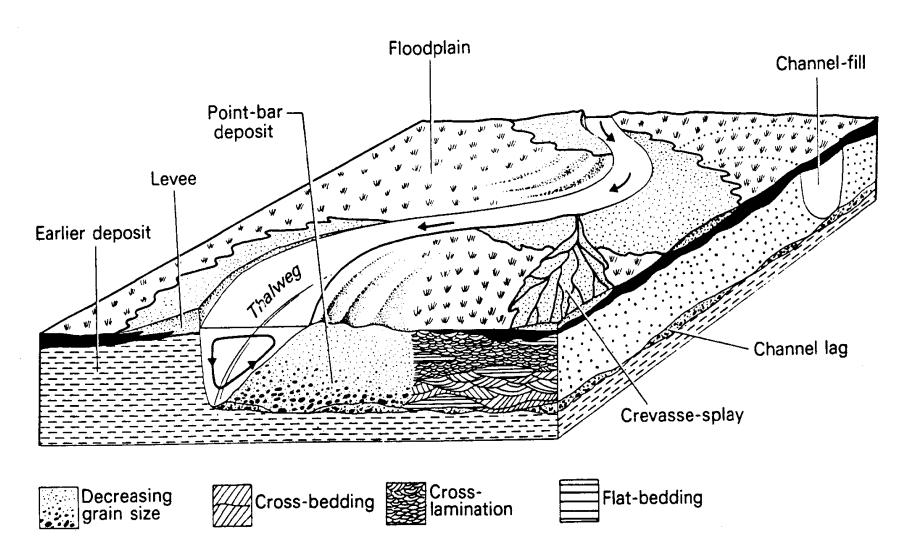


PRIMARY COMPONENTS OF A FLUVIAL GEOMORPHIC SYSTEM

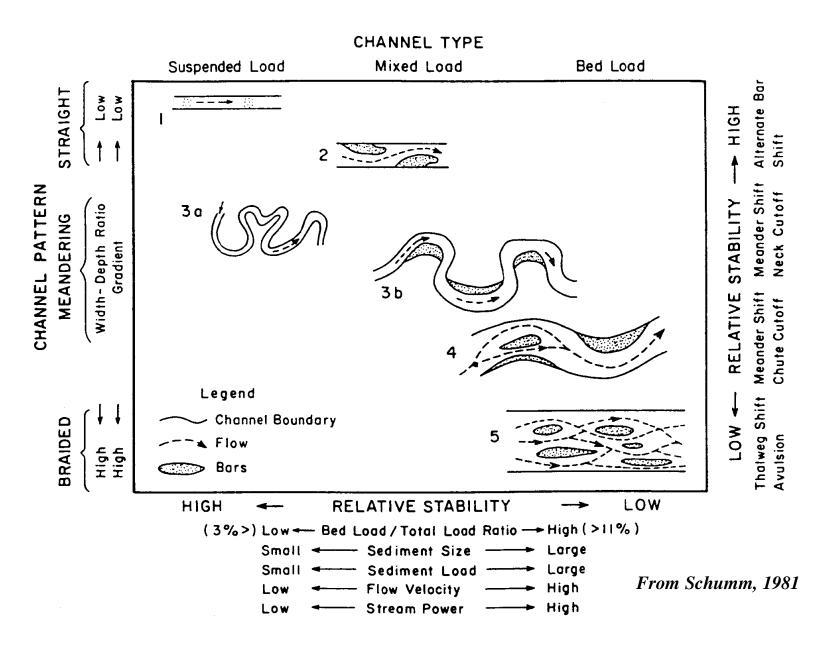


HISTORIC IMPACTS ON FLUVIAL GEOMORPHIC SYSTEMS

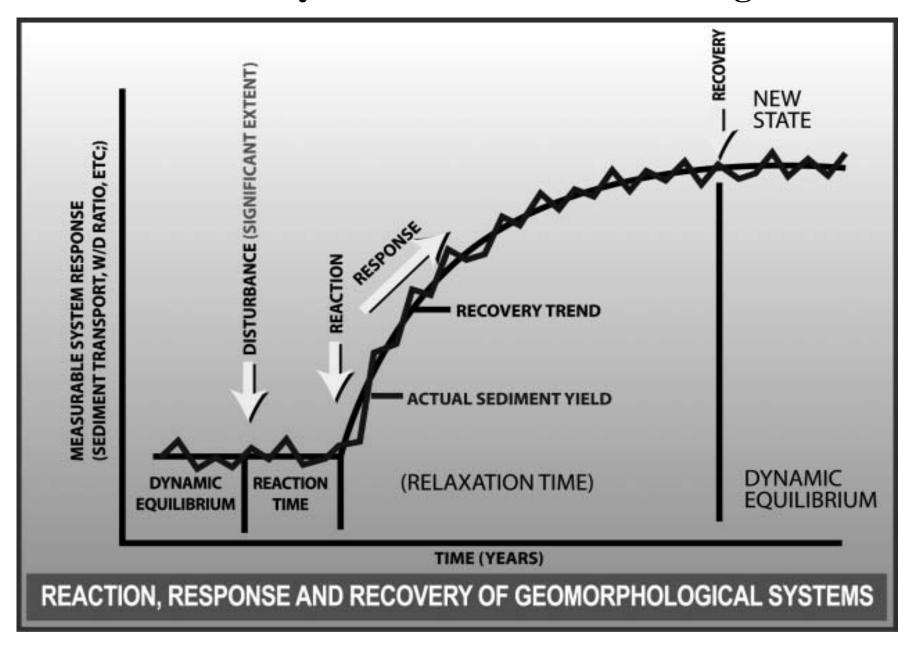
# Landforms-Typical Surface and Subsurface Conditions

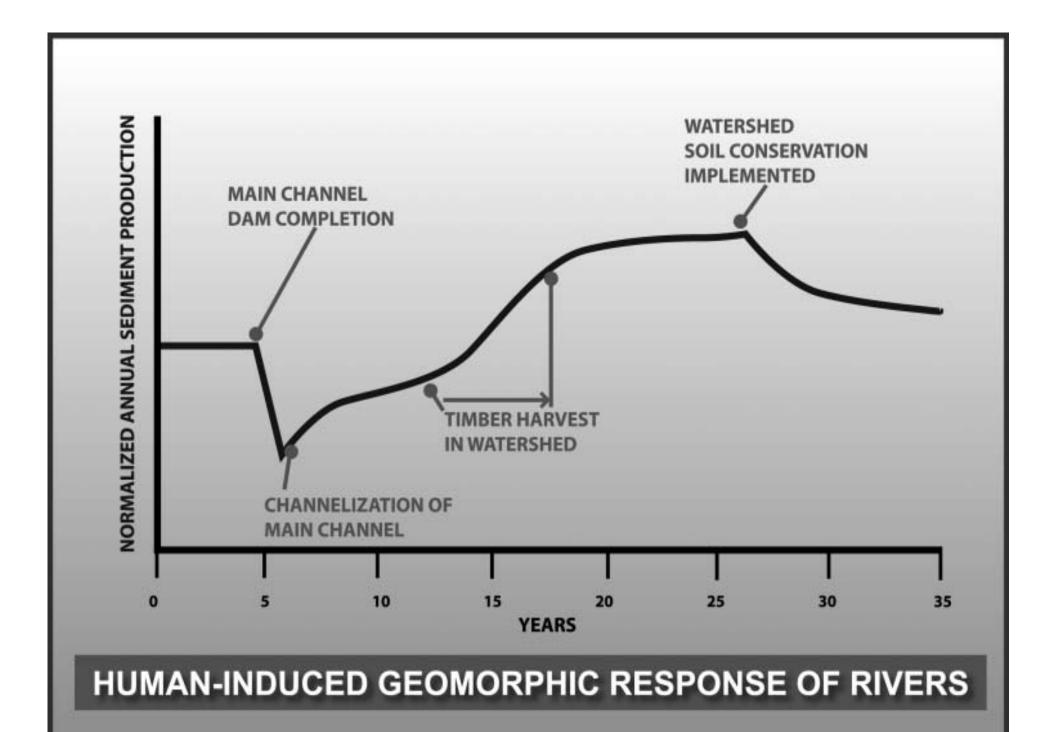


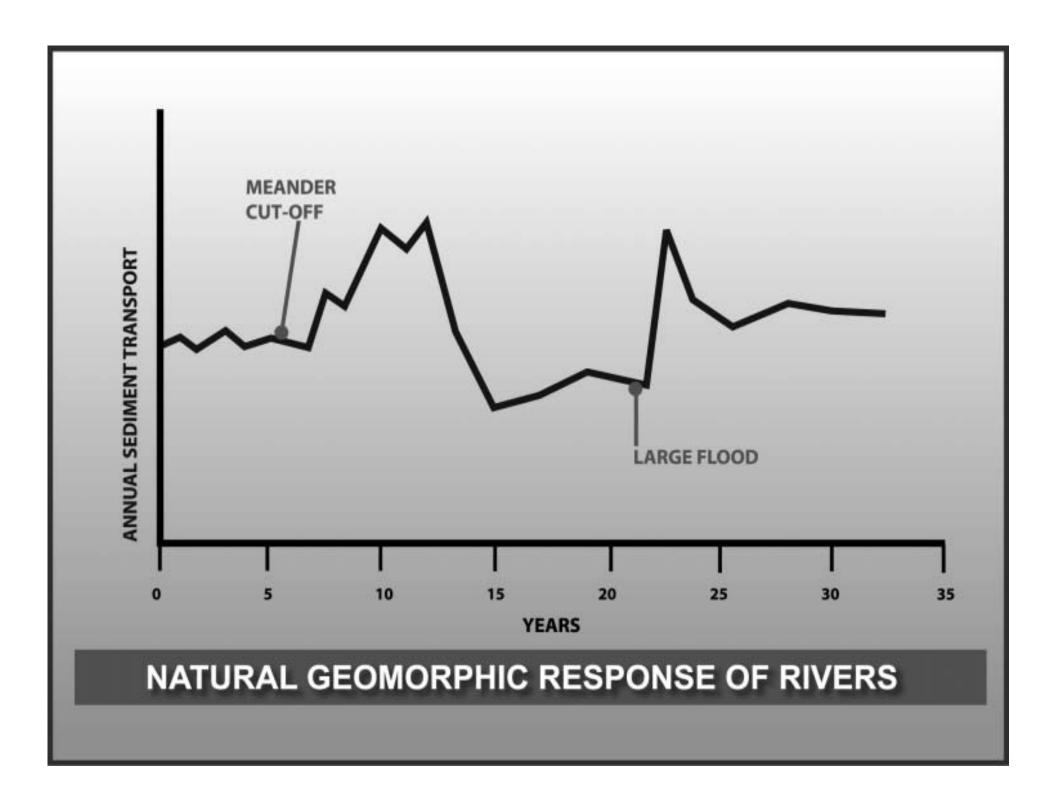
### Geomorphic Process-Landform/Sediment Products



#### **Uniformity and Environmental Change**





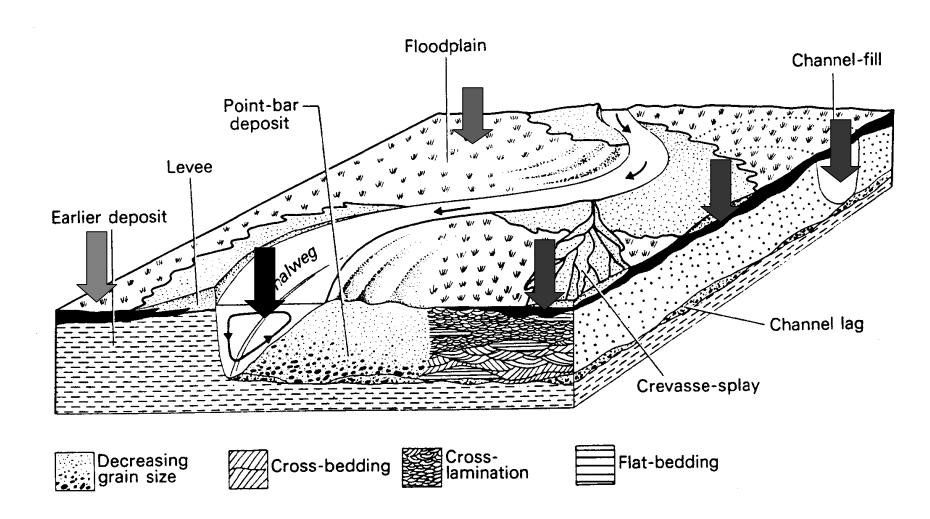


#### ENGINEERING GEOMORPHOLOGY

# IMPORTANCE TO CONTAMINATED SEDIMENT MANAGEMENT

# Where do contaminated sediments occur at or near the surface?

#### **Locations of Contaminated Sediments**



# Where do contaminated sediments occur at or near the surface?

**Concept:** Landforms-typical surface and subsurface conditions.

**Data:** Historic maps, aerial imagery, topographic maps, streamflow data, subsurface sampling, analysis and testing of samples.

**Products:** Maps of contaminated sediment occurrence, explanation of historic deposition of contaminated sediments

What are the magnitude, frequency, and duration of processes controlling the long-term stability of contaminated sediments?

# Geomorphological Processes Influencing the Stability of Contaminated Sediments

<b>PROCESS</b>	IMPACT	<b>ENVIRONMENT</b>
Erosion	<b>De-stabilizing</b>	Water column
Transport	<b>De-stabilizing</b>	Water column
<b>Deposition</b>	<b>Stabilizing</b>	Water column
Bioturbation	<b>De-stabilizing</b>	Substrate
Dessication/hyd.	Both	<b>Ground surface</b>
Freeze/thaw	Both	<b>Ground surface</b>
Biogeochemical	Both	Substrate
Consolidation	<b>Stabilizing</b>	Subsurface

**Continued** 

# Geomorphological Processes Influencing the Stability of Contaminated Sediments

<b>PROCESS</b>	IMPACT	<b>ENVIRONMENT</b>
Settlement	Both	Subsurface
Collapse	<b>De-stabilizing</b>	Subsurface
Compaction	Stabilizing	Subsurface
Cementation	Stabilizing	Subsurface
Disentegration	<b>De-stabilizing</b>	<b>Ground surface</b>
<b>Decomposition</b>	Both	<b>Ground surface</b>
Dispersion, piping	<b>De-stabilizing</b>	Subsurface
Liquifaction	<b>De-stabilizing</b>	Subsurface

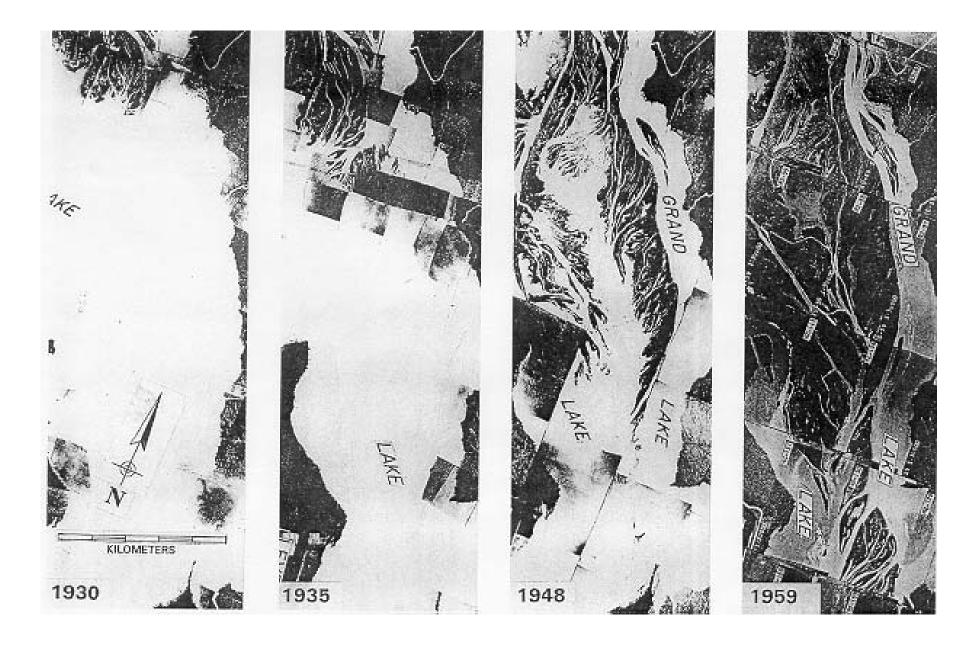
What are the magnitude, frequency, and duration of processes controlling the long-term stability of contaminated sediments?

Concepts: Geomorphological systems, elements, processes, and linkages

**Data:** Historic topographic maps, hydrographic charts, and aerial photographs; meterological, sedimentological, geochemical and soil physics data

**Products:** Graphical and numerical descriptions and analyses of the processes that cause and/or influence sediment instability.

### Historic Filling of Grand Lake, Louisiana



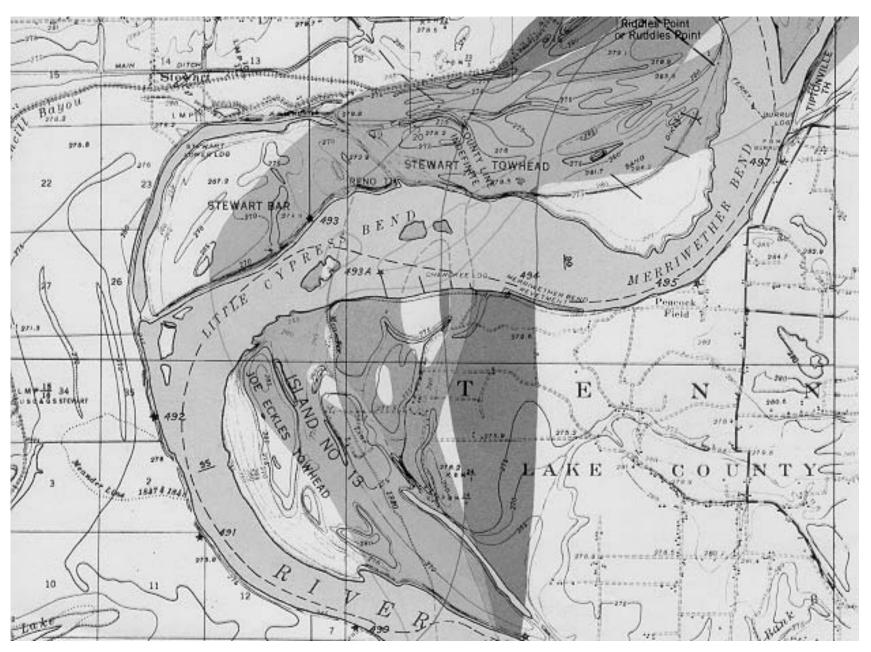
How do the magnitude, frequency, and duration of contaminated sediment processes vary in time and space?

**Concepts:** Geomorphic process – landform relationships

**Data:** Historic topographic maps, hydrographic charts, and aerial photographs; meterological, sedimentological, biogeochemical and soil physics data; sediment age dating; biogeochemical data.

**Products:** Maps, diagrams, and other graphical portrayals of the distribution of processes influencing sediment instability as a function of space and time.

### Historical Changes of the Mississippi River

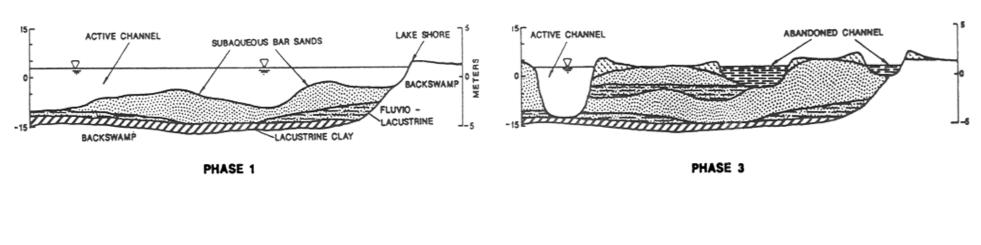


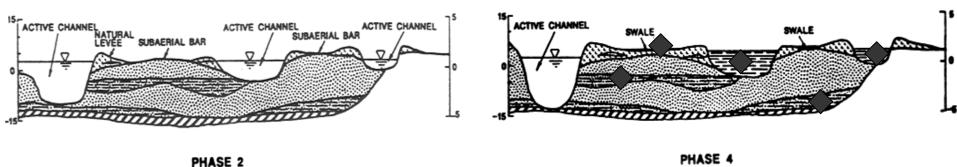


Lower Ohio River: A relatively stable channel system

What is the probability that contaminated sediments will be buried by clean sediments or exposed to re-mobilization?

### Historical Development of Deltaic Lobes Grand Lake Louisiana





Potential locations of Contaminated sediment



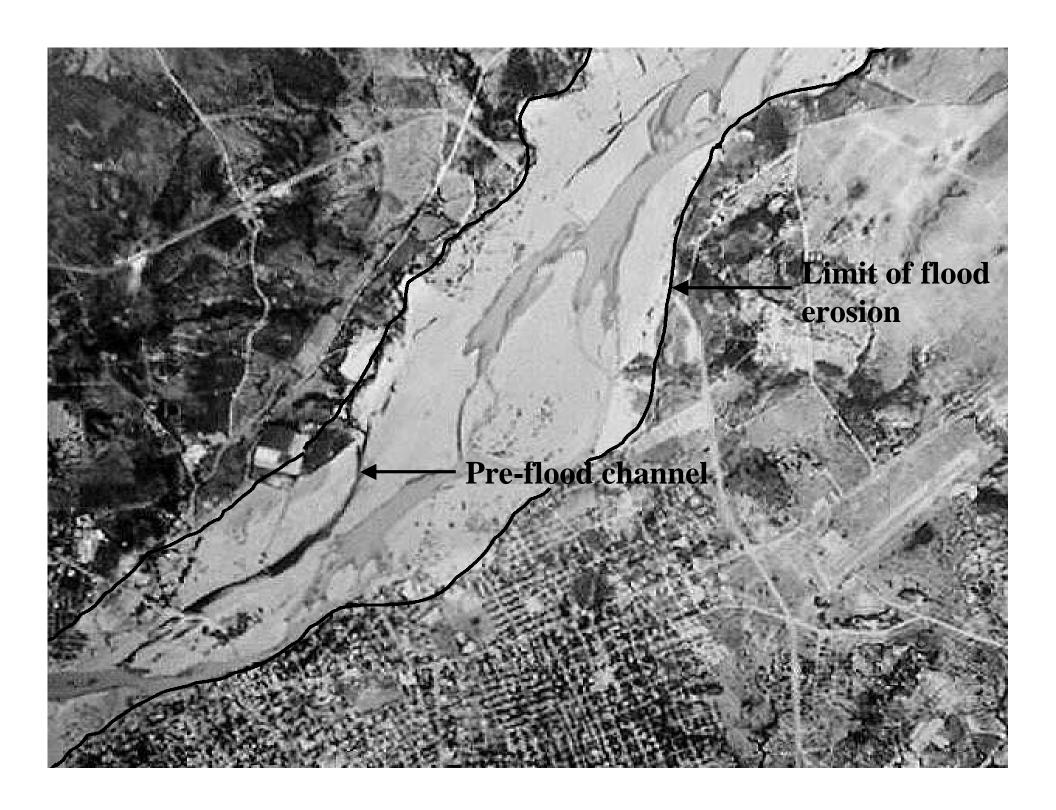
What is the probability that contaminated sediments will be buried by clean sediments or exposed to re-mobilization?

Concepts: Geomorphological systems structure, components, linkages, and dynamics.

**Data:** Streamflows, sediment transport, hydrographic surveys, waterborne geophysical data, topographic maps, aerial photographs, laboratory analyses of sediment samples.

**Products:** Sediment budget for areas of concern, including specific locations; Predictions of sediment movement at specific locations.

# What will be the impact of large storms and other significant events on contaminated sediments?





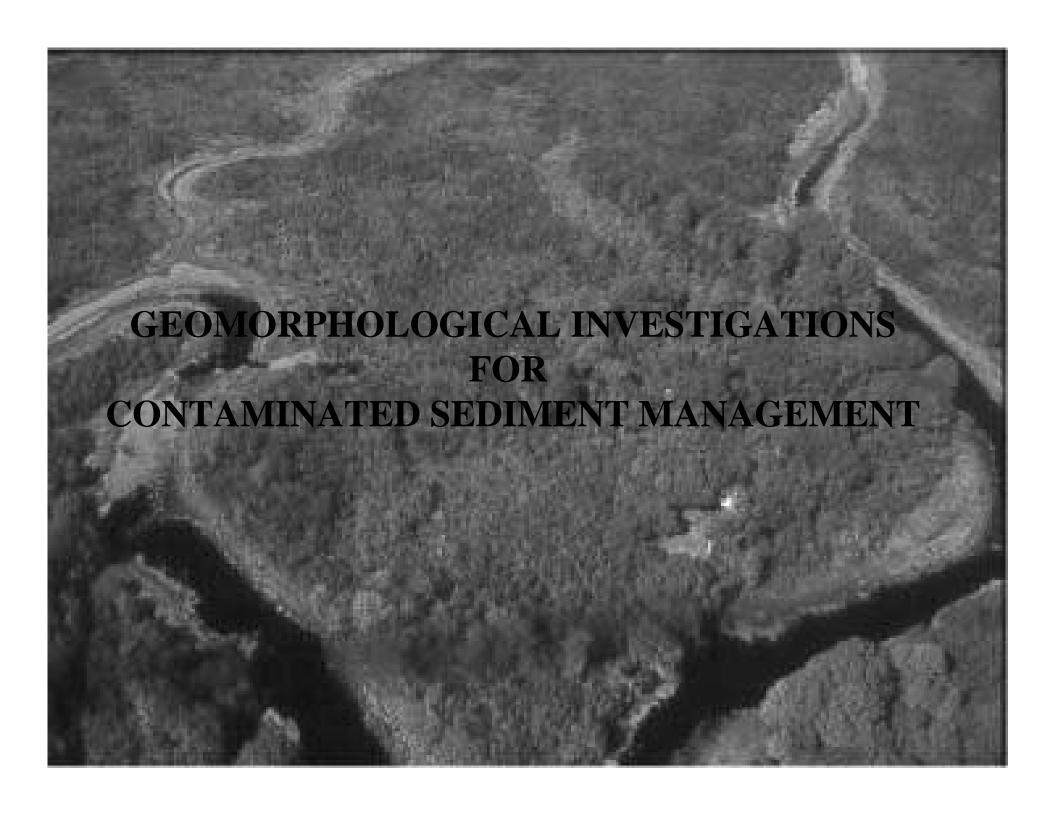
**Minimally Impacted Stream System** 

What will be the impact of large storms and other significant events on contaminated sediments?

Concept: Uniformity and environmental change.

**Data:** Streamflows, sediment transport, hydrographic surveys, waterborne geophysical data, topographic maps, aerial photographs, laboratory analyses of sediment samples.

**Product:** Predictions of the impacts of large flow events on sediment stability and location.



### GEOMORPHOLOGICAL INVESTIGATION ACTIVITIES

- *Identification and delineation* of features, conditions, and processes
- *Measurement and description* of features, conditions, and processes
- Analysis of processes, factors, and systems
- *Testing* of hypotheses and analysis of *uncertainty*

**Continued** 

#### GEOMORPHOLOGICAL INVESTIGATION ACTIVITIES

- **Reconstruction** of past conditions and processes
- *Explanation* of the impact of geomorphic processes upon the project
- *Prediction* of future conditions and processes
- *Prescription* of conceptual solutions to meet project goals

Concluded

### GEOMORPHOLOGICAL INVESTIGATION METHODS

- Field investigations
- Interpretation and analysis of imagery
- Geographic information systems
- Laboratory testing, analysis, and modeling
- Development of conceptual models
- Development of numerical models
- Evaluation of engineering designs and actions

#### **MESSAGE**

Contaminated sediment management requires a comprehensive and systematic understanding of the processes and conditions that were responsible for their transport, deposition, burial, and re-exposure.

Detailed geomorphological investigations will provide an invaluable foundation to the development of scientifically based management strategies.

